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Ventilation Requirements for Airtight Homes

A RESEARCH REPORT

Ventilation Requirements for Airtight Homes

A RESEARCH REPORT

A Summary of Ventilation
Requirements for
Airtight Homes in Canada

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ABSTRACT/RESUME

As airtight houses become more popular across Canada, reduced ventilation rates may lead to poor air quality and high humidity problems in these dwellings. This working paper reviews the needs for ventilation, ventilation methods and systems, and current codes and standards, particularly with respect to airtight and energy efficient houses. Current research in Canada is reviewed and considerations for a new ventilation standard are discussed.

* * *

Au fur et à mesure que les maisons étanches à l'air gagnent en popularité au Canada, les taux réduits de ventilation peuvent créer des problèmes de qualité d'air et de niveau d'humidité trop élevé. Ce document de travail passe en revue les besoins et les méthodes de ventilation dans les résidences étanches à l'air et à haut rendement énergétique ainsi que les normes et codes actuels.

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This report has been prepared by T E S Limited for internal review at the Ontario Research Foundation and is intended to have limited circulation. The sponsoring agency is Energy, Mines and Resources Canada, through the Buildings Energy Technolog Transfer (BETT) Program.

The aim of the BETT Program is to promote the widespread adoption of energy conservation by providing the required technological know-how and effecting its delivery to the appropriate end users.

A large volume of information has been accumulated on residential ventilation. The pertinent highlights of the reviewed material are presented in this report. More detailed information concerning any particular topic can be found using the references and bibliography.

Due to the nature of this report, passages are occasionally quoted directly from the source. In such cases, an acknowledgement in the form of a reference number has been provided.

Throughout this report ventilation rates are presented in terms of air changes per hour (ach) or in litres per second (L/s). One L/s is considered equivalent to 2 cubic feet per minute (cfm).

Statements made in this report do not necessarily reflect the views, attitudes, opinions or policies of the Ontario Research Foundation or Energy, Mines and Resources Canada.

Dans les vieilles maisons et dans certains maisons plus récentes, la ventilation n'est généralement pas controlée, et dans certains cas, elle est un phénomène strictement accidentel. Cependant, l'intérêt sans cesse croissant a vouloir économiser l'énergie a fait que l'enveloppe des constructions est devenue, plus étanche à l'air, les niveaux d'isolation thermique ont été occasionné des problèmes de qualité d'air et d'augmentation du niveau d'humidité ainsi que d'autres problèmes, entre autre, l'utilisation des appareils de chauffage au mazout ou au gas dans les résidences à haut rendement énergétique.

Cette évaluation des besoins en ventilation indique qu'un taux de ventilation minimum de 0,5, changement d'air à l'heure (approximativement 50 L/s) est nécessaire pour assurer un niveau adéquat de qualité d'air dans les résidences très étanches à l'air. Un contrôle précis du taux de ventilation dans les résidences très étanches à l'air va sans doute nécessiter une ventilation mécanique, possiblement en conjonction avec un système de recuperation de la chaleur.

Ventilation is the process of supplying or removing air, to or from a space, by either natural or mechanical means in order to maintain an acceptable level of air quality. The air supplied for this purpose usually comes from the outside, either intentionally through an opening that is controlled manually or automatically, or unintentionally by air leakage through the building envelope.

In older housing and in some recent housing, ventilation has usually been uncontrolled, and, in most cases, may be regarded as accidental. Such informal control of building ventilation has been considered acceptable in the past. However, with the current increased interest in energy conservation, measures are being taken to conserve the amount of energy used in the heating and cooling of buildings. Building envelopes have been tightened, insulation levels increased and ventilation rates reduced. These measures have lead to problems of poor air quality and high humidity levels. In addition, serious problems have been encountered with the use of combustion devices in airtight houses.

The Ontario Research Foundation (ORF) is currently undertaking a technical review of airtight homes for Energy, Mines and Resources Canada. Part of this review includes documenting ventilation requirements for these houses. This working paper has been prepared by T E S Limited for the Ontario Research Foundation. It provides technical background information on ventilation requirements, ventilation methods and systems, current codes and standards, and current research in the area. Considerations for a new ventilation standard are also presented.

The objective of this program was to produce a technical background paper on ventilation requirements for airtight houses. This paper is to be used as input to a builders' guide to be prepared for the residential building sector. In addition the paper may serve as input for a codes and standards committee which is reviewing ventilation requirements for airtight homes.

The project included a review of current published material relevant to ventilation of residential buildings, as well as a review of appropriate codes and standards both current and proposed. In addition, the program involved the documentation of work currently being carried out in the area of residential building ventilation requirements. The material was reviewed with a view to assessing its potential impact on any proposed new ventilation standard.

The work covered ventilation requirements for residential buildings excluding apartments, with emphasis on energy efficient housing. Retrofits and modifications to existing buildings were not considered.

In an attempt to obtain all relevant published information, contact was made with numerous groups in both Canada and the United States, who have been working in the area of building ventilation. In addition to ORF, this included the following organizations:

- Energy, Mines and Resources Canada, Conservation and Renewable Energy Branch
- National Research Council, Division of Building Research
- Canada Mortgage and Housing Corporation, Technical Research Division
- Ontario Ministry of Energy, Conservation and Renewable Energy Group
- Canadian Government Standards Bureau
- Saskatchewan Research Council
- University of Saskatchewan
- Indian and Northern Affairs Canada
- Health and Welfare Canada
- Housing and Urban Development Association of Canada
- Lawrence Berkeley Laboratories, University of California
- Princeton University
- U.S. Department of Commerce, National Technical Information Service

A more detailed listing of organizations and people contacted is given in Appendix "A".

In addition to these personal contacts, which provided a wealth of information on published literature and current research, use was made of the computer data base search capabilities of the Canada Institute for Scientific and Technical Information (CISTI). The data bases to which CISTI has access include information published in scientific reports, periodicals and reference books.

Key words chosen included ventilation, ventilation rates, building codes, building standards, infiltration, and air quality.

While the rather tight time frame of the study may have precluded contact with all groups carrying out research in the area of residential building ventilation, the cross referencing between research groups and the repeated references to particular publications which were evident during our study, would indicate that most major works were considered or included in this review. For detailed information on specific topics, certain of these publications are referenced throughout the body of this report, and the reader should note that review of at least the referenced documents is necessary for a comprehensive evaluation of residential ventilation requirements. The bibliography section of this report contains details on all relevant material reviewed during the program.

AIR QUALITY

A residential building must be adequately ventilated in order to maintain an acceptable level of air quality within the dwelling. The needs for such ventilation usually result from the necessity to:

- maintain proper oxygen and carbon dioxide levels,
- control the concentration of contaminants that may produce objectionable odours or toxic effects,
- control the humidity level within the building in winter, and
- reduce discomfort from overheating in summer.

Metabolic Gases

Fresh outdoor air contains about 21% oxygen and 0.03% carbon dioxide on a volume basis. Significant variations in these proportions can render it unfit for human use. For prolonged exposure, a minimum concentration of 16% oxygen and a maximum concentration of 0.5% carbon dioxide are commonly accepted standards. Oxygen deficiency in itself is not as serious a problem in poorly ventilated quarters, as high carbon dioxide concentration, which can cause unconsciousness or death before a corresponding oxygen deficiency would have serious physiological effects (1). In order to establish a satisfactory balance between the metabolic gases (oxygen and carbon dioxide) in an occupied environment, a ventilation rate of 1 to 3 L/s per person is required depending on the level of activity (1,2,3).

Contaminants

Indoor contaminants include odours, particulates, products of combustion, formaldehyde, radon and assorted chemicals from household cleaners and solvents. In general, the ventilation rate required to establish an acceptable indoor air quality varies according to the contaminant and the susceptibility and sensitivity of the occupants to that contaminant.

Odours

Odours in buildings can emanate from many sources including building materials, food products, tobacco smoke, garbage, pets and humans. Many of these sources of household odour are intermittent and continuous removal is not required. Past research has identified body odours and tobacco smoke as the largest contributors and, if these odours are controlled by dilution, other odours will remain

within acceptable limits as well. Recent work has indicated that the required air supply rate is not directly proportional to the number of persons. Rather, the required air supply rate per person decreases as the number of persons in a given volume increases (4). Typical ventilation rates for odour control range from 2 to 15 L/s per person for most situations (1,3).

Particulates

A variety of airborne particles such as dust, smoke, pollens and bacteriological organisms may be contained in the outdoor air brought inside for ventilation while higher concentrations of these contaminants may be generated indoors by the activities of the occupants. Airborne particles are usually removed by circulation through an air-cleaning device such as an air filter for the removal of larger dust and fibre particles or an electrostatic air cleaner to remove finer particles such as pollen and tobacco smoke. As well, the normal ventilation process of bringing in fresh air helps to reduce the concentration of the particles to an acceptable or unnoticeable level.

Combustion Products

Carbon monoxide and oxides of nitrogen (usually nitrogen dioxide) are generated by combustion appliances, such as furnaces, stoves, heaters or fireplaces. The rate of generation depends on the size and efficiency of the appliance. If these combustion devices are properly vented outdoors, then no additional ventilation is required to maintain indoor air quality. However, research indicates that unvented gas stoves can produce large amounts of nitrogen dioxide and carbon monoxide (5,6). Laboratory studies have shown that a ventilation rate from 25 to 50 L/s is required to keep these toxic gas concentrations within the limits established by air quality health standards (7).

Formaldehyde

Formaldehyde is an inexpensive, high volume chemical which is used in a wide variety of building materials such as insulation, particleboard, plywood, textiles and adhesives. It is a known irritant and a suspected carcinogen (6,8). Its concentration depends on the building materials used and the age of the house (emissions decrease as the house gets older). Formaldehyde and other aldehyde levels were measured by the Lawrence Berkeley Laboratory at several energy efficient research houses at various geographic locations in the United States. It was

found that, at low ventilation rates (< 0.3 ach), the indoor formaldehyde and aldehyde concentrations often exceeded the promulgated European indoor standard of 0.1 ppm while outdoor concentrations during these studies were typically 0.016 ppm or less (9). Other studies have indicated that an air change rate of 0.5 ach might be required to achieve acceptable control of formaldehyde (2).

Radon

Radon and its decay daughters are known to contribute a significant portion of natural background radiation exposure to the population. Scattered observations have shown that indoor concentrations of radon and radon daughters are typically higher than outdoor concentrations. This is presumably because the building structure serves to confine radon entering the indoor environment from various sources. Radon is an inert, radioactive, naturally-occurring gas that forms from the radioactive decay of radium, which in turn results from the radioactive decay of uranium. Since radium is a trace element in most rock and soil, sources of indoor radon include the soil under building foundations and building materials, such as concrete or brick. Tap water may be an additional source if taken from wells or underground springs. Thus, radon concentration is influenced by geographical location (certain building sites are known to have high levels of radon emission) (10) and the building materials used. Research has indicated that a ventilation rate of approximately 0.5 ach will limit radon concentrations to within health guidelines (2,9). However, there is still a great uncertainty with regard to the deleterious health effects from radon (2).

Humidity

Although it is essential to maintain proper metabolic gas levels and control the concentration of contaminants in the indoor air, there is little question that the control of humidity levels within the building envelope during the winter is one of the prime functions of a ventilation system. In older houses, it is generally difficult to maintain sufficient moisture in the air, but in modern well sealed homes the situation is reversed and high humidity levels are more prevalent. In the wintertime, high humidity levels can lead to excessive condensation of moisture on windows, walls and ceilings. In addition, more serious problems can occur when water vapour is permitted to condense within the insulation inside walls, crawl spaces and attics. Such condensation can cause deterioration of

the insulation and building structure and may seriously affect the structural integrity of the building.

The principal sources of moisture in a typical house are from household activities which vary with the living habits of the family. Moisture can be produced by such activities as cooking, dishwashing, personal bathing and showering, washing and drying clothes, as well as human contributions through respiration and perspiration. Other sources of moisture include plants, use of humidifiers, evaporation from exposed soil in crawl spaces, release of moisture from various materials used in construction and leakage of outside water through the building envelope. In general, increases in moisture from these sources will lead to increased humidity levels inside the building and may cause moisture problems within the building in the winter months.

Excess moisture and high humidity levels within a house can be controlled by eliminating or reducing the sources of moisture, isolating areas which are susceptible to moisture (walls, attics, etc.) and by ventilation. In fact, in modern houses all of these methods of humidity control are typically employed to varying degrees.

The amount of ventilation required in winter to control the build-up of humidity inside the house depends on several factors such as the number of occupants and the amount of moisture produced. However, it is generally accepted that a rate of ventilation below about 0.25 ach will result in the formation of condensation (9). The results of a large number of studies on the indoor humidity problem indicate that a continuous ventilation rate from 30 to 50 L/s is required to control the moisture build-up in a typical Canadian home during the winter (9,11).

Summer Ventilation

Often, so much emphasis is placed on providing adequate ventilation in winter to control air quality and humidity, that little thought is given to summertime ventilation. However, ventilation does play an important role in providing comfort from overheating in the summer. In dwellings without summer air conditioning systems, ventilation with outdoor air can be used to dissipate internal heat

gains and heat gained from solar radiation. Such ventilation is usually achieved using large operable windows, strategically arranged to provide cross-ventilation through the house and to take advantage of natural air currents and stack effect.

COMBUSTION DEVICES

If a fuel-fired device is located inside a house, then air must be supplied for the combustion process and draft control. The amount of air required depends on the type, size and efficiency of the device. Typical air requirements for combustion equipment are: airtight wood stove (5 L/s), gas hot water heater (10 - 15 L/s), conventional gas furnace (45 L/s), conventional oil furnace (70 L/s), gas clothes dryer (100 L/s) and conventional fireplace (200 L/s) (12).

In an airtight/energy efficient house, the space heating load is low and combustion furnaces with relatively small outputs are normally specified. Thus, the air requirements for combustion furnaces in airtight/energy efficient houses may be considerably smaller than in conventional houses. For example, in a house with both a natural gas furnace (rated at 9.2 kW) and domestic hot water heater (12 kW), it has been determined that the combined air supply requirement (when both are operating simultaneously) is about 18 L/s (13, 14).

COMPETITION BETWEEN AIR CONSUMING DEVICES

In addition to combustion devices, a house may contain other air consuming devices such as simple exhaust fans (usually located in the kitchen and bathroom), a heat exchanger, a clothes dryer, a cooking grill, or a central vacuum system which may be vented outdoors. The air requirement of such devices depends on fan size and speed of operation but typical air demands are in the range of 25 to 100 L/s, although a vented grill may require up to 200 L/s.

Assume an airtight house with a properly balanced and operating ventilation system. If the house does not contain any combustion devices, then the intermittent use of air consuming devices may cause short term unbalancing of the ventilation system but will be unlikely to have any long term deleterious effects. However, if the house contains a combustion device with a large air requirement (such as a fireplace or large gas or oil furnace), then interaction between

the ventilation system and the combustion units is likely and may lead to downdrafting and the release of toxic combustion gases indoors. The intermittent use of other air consuming devices may increase the likelihood of such flow reversals in the venting system of the combustion devices.

If the airtight house is energy efficient and equipped with small capacity combustion devices, then the ventilation system may be capable of also supplying the combustion and draft air supply requirements. However, possible interactions between the ventilation system and the combustion units are unpredictable and may be quite strong if other air consuming devices are used randomly. In addition, a failure or accidental blockage of the ventilation system could lead to the release of combustion products inside the house. Thus, it is possible that in airtight houses, the competition between air consuming devices may require separate air supplies for the ventilation system and for combustion and draft air supply.

A summary of the ventilation requirements mentioned in this section is presented in Table 4.1. In reading this table, it should be kept in mind that the individual ventilation rates for air quality are non-cumulative while those for combustion and air consuming devices are cumulative.

Table 4.1 Summary of Ventilation Requirements

Ventilation Purpose	Ventilation Rate Required L/s	ach	Comments
AIR QUALITY			
- Metabolic Process	1 - 3		Per Person
- Odour/Smoke Control	2 - 15		Per Person
- Control of Combustion Products	25 - 50		
- Formaldehyde Control		0.3 - 0.5	
- Radon Control		0.5	
- Humidity Control	30 - 50		For Typical Family
COMBUSTION DEVICES			
- Airtight Wood Stove	5		
- Gas Water Heater	10 - 15		
- Conventional Gas Furnace	45		
- Conventional Oil Furnace	70		
- Gas Clothes Dryer	100		
- Conventional Fireplace	200		
- Gas Water Heater (12 kW) and Gas Furnace (9.2 kW)	18		In an Airtight/ Energy Efficient House
AIR CONSUMING DEVICES			
- Typical Devices Vented Outdoors	25 - 100		Exhaust Fans, Heat Exchanger, Clothes Dryer, Vacuum, Etc.
- Vented Grill	200		

Ventilation can be categorized as either natural or mechanical. Natural ventilation is the movement of air into and out of the house, unassisted by mechanical means such as fans. This may take place through planned openings such as open windows, chimneys or stacks, or through unplanned leaks in the building envelope. Mechanical ventilation is the movement of air into and out of the house through planned openings, assisted by mechanical means such as intake and exhaust fans.

Natural Ventilation

Weather (primarily temperature, and wind speed and direction) exerts a strong influence on the natural ventilation of houses. The greater the temperature difference between inside and outside, the greater the driving force for infiltration and exfiltration. Below the neutral pressure plane, the interior pressure is less than the exterior pressure and above the neutral pressure plane the interior pressure is greater than the exterior pressure. These pressure differences cause infiltration and exfiltration below and above the neutral pressure plane, respectively. Temperature differences of from 1 to 20°C can cause pressure differences of from 0.1 to 2.5 Pa, respectively, for a typical single family house (3).

Wind speed and direction control the magnitude and distribution of external pressures on the building, resulting in shifts in the neutral pressure plane and changing the air infiltration rate. It is difficult to correlate the change in ventilation rate to wind speed and direction, however, because the surface pressure distribution depends on the shape of the building, the height above ground, and the presence of windbreaks such as other buildings, hills and trees. Typical values for the range of pressure differences created by winds, of from 3.5 to 35 km/h, are 0.1 to 60 Pa, respectively (3).

Natural ventilation is also greatly influenced by building configuration. The position of the neutral pressure plane (and consequently the infiltration rate) is affected by the placement of floors, walls and doors within the building envelope. Obviously construction details such as workmanship that affect tightness will also influence ventilation rates. As well, chimneys or stacks connected to the interior will raise the neutral pressure plane and will reduce the tightness of a house (15).

A recent study of the airtightness of houses in the Saskatoon area gives an indication of the variation in tightness and, consequently, the natural air change rates to be expected. It was found that the age of the house was the most significant variable influencing airtightness. The average airtightness for pre 1945 houses was 10.35 ach at 50 Pa, for houses built between 1945 and 1960 it was 4.55 ach, and for post 1960 houses it was 3.57 ach. There was an approximate 2.2 to 1 variation between the airtightness values of the contractor with the tightest houses and the contractor with the loosest houses (16).

Occupant habits, mainly the opening and closing of doors and windows and the use of kitchen and bathroom fans, can significantly alter the ventilation rate. Little research has been done on quantifying the effect of human factors. The work that has been done indicates a possible ventilation rate of up to 20 ach due to the opening of windows in a naturally ventilated house (17,18).

Given the wide variability in ventilation rates resulting from the effect of the above factors on natural ventilation, it is not simple to design an energy efficient building utilizing this approach. For this reason, newer housing, and particularly super energy efficient housing is taking the approach of sealing the building envelope as tightly as possible to eliminate unplanned natural ventilation, and to replace it with mechanical ventilation.

Mechanical Ventilation

Mechanical ventilation is finding widespread use in energy efficient homes to replace the natural circulation lost as the airtightness of the building envelope is increased. Strictly speaking, the proper term for these ventilation systems would be natural/mechanical ventilation systems, to account for the fact that there is always some component of the air change due to natural ventilation, as it is virtually impossible to construct a completely airtight house. However, current practice refers to systems where fans are the primary air mover as mechanical ventilation systems.

The advantages of any mechanical ventilation system over natural ventilation include a greater control over the ventilation rate and the pressure

differences between exterior and interior. There are also more options for the installation of accessories such as filters or heat exchangers.

A mechanical ventilation system consists of two major parts, exhaust equipment to remove contaminants and excess humidity, and intake equipment to provide air required as make up for the exhaust, for metabolic purposes, and for any combustion devices. Exhaust equipment may be localized in order to remove contaminants as close to the source as possible, as in the case of bathroom or kitchen exhaust fans, or it may be centralized, with exhaust registers at various locations throughout the house. Similarly the intake methods used may be localized, for example to provide air to a combustion device such as a fireplace or a furnace, or they may be centralized, with distribution systems to deliver the fresh air to various locations in the house.

Guidelines for Mechanical Ventilation Systems

There are currently no definitive rules or guidelines for the design and installation of mechanical ventilation systems for airtight houses. Most house builders appear to be trying to adapt ventilation systems for conventional houses to airtight houses, sometimes with little success. In order to help resolve this situation, a project is currently being conducted by the Housing and Urban Development Association of Canada to provide guidelines for the design and installation of controlled ventilation systems for airtight houses. A summary of this project (12) presents recommended layouts for the ventilation intake and exhaust systems. These recommendations are presented on the following pages with appropriate comments. Note that these systems do not attempt heat recovery as discussed later in this section.

Intake equipment for houses with forced air duct work:

- intake from the outdoors passes through the basement wall to the basement return air duct before the return duct reaches the return air plenum of the furnace;
- this intake duct to be insulated, contain no dampers, but may have an orifice plate to adjust intake flow;

- pre-heat coil in the intake duct is an option;

- the intake duct is designed to provide the same pressure drop as the return air duct. The furnace fan (running at low speed continuously and high speed when the furnace burner is on) helps draw air through the inlet duct;

- this duct to be mounted in the upper portion of the basement wall and away from corners of the house where wind currents could interfere with air flow.

Comments: If the intake duct from outdoors goes directly into the furnace return air system, problems may be encountered trying to balance the ventilation system. In addition, if the pre-heat coil is not used, condensation problems may arise in the furnace return air system. An alternate approach would be to allow the intake duct to discharge fresh air into the basement area near the cold air return duct. A grill on the return air duct could then be used to capture this fresh air and to duct it to the furnace plenum. Similarly, the intake duct could discharge fresh air into a hallway. The fresh air would then return to the furnace via the normal cold air return system. However, discharging into a hall area might cause discomfort problems unless the pre-heat coil is used and might lead to extended furnace run times if the thermostat is located in or near the hall.

If the intake duct goes directly into the return air duct, it is possible to design the same pressure drop in each duct. However, it may be difficult to ensure proper airflow in the intake duct at both high and low speeds of the furnace fan.

Intake equipment for hydronic and electric baseboard and radiant heating systems consists of the following:

- intake duct passes the upper portion of the basement wall and is insulated in the basement;

- duct continues to an outlet in the basement, and as options, in the first floor hall, and in the second floor hall;

- pre-heat coil in the intake duct is recommended, because of lack of opportunity for intake air to mix with warm interior air prior to discharge into parts of the house;

- fresh air supply outlets provided in the first floor hall and second floor hall should be installed as far away as possible from the bathroom and kitchen exhaust grilles (see below) to promote maximum mixing.

Comments: In order to promote air circulation throughout the entire house, the intake duct could continue to outlets in all habitable rooms. Such a layout would provide fresh air but would also require extensive use of the pre-heat coil to prevent discomfort due to an excessively cold air supply.

Exhaust equipment is selected to form a central exhaust system as follows:

- exhaust equipment consists of one central exhaust fan drawing from each bathroom and kitchen. Air is exhausted through a duct down to the basement along the ceiling and through the basement wall;

- install a back draft damper between the kitchen exhaust grille and the ducts to the bathroom;

- a manual balancing damper may be used at the outlet to closely match exhaust air volume flow rate with ASHRAE requirements;

- kitchen exhaust grille should be mounted on a wall away from the stove to avoid grease build up;

- to promote air quality in the immediate area of the stove, use a re-circulating fan over the stove with charcoal filter;

- undercut all interior doors to provide a 25 mm gap between the underside of the door and the finsihed floor;

- mount exhaust outlet in upper portion of the basement wall, away from corners of the house, and about 2 metres from the intake duct.

Comments: The exhaust and intake system layouts are designed in such a manner that a heat recovery device could be incorporated into the ventilation system with little additional cost other than for the device itself. Although one central exhaust fan may be used, local exhaust fans might also be required in certain locations (bathroom, workshop, etc.) for intermittent use. However, such localized high volume ventilation can create balancing problems.

In the case of a house where indoor air is not relied upon for combustion air supply (example, electric space and domestic hot water heating), the design of the ventilation system can be relatively straight forward, with a negative pressure being maintained inside the house to minimize moisture exfiltration through the building envelope, with its resulting problems. However, conventional combustion devices such as gas fired space or water heaters rely on pressure differences created by stack effect in order to exhaust the combustion products, and this must be taken into account when designing the ventilation system.

Combustion Devices

A recent report prepared by ORF suggests a number of approaches to deal with the problem of supply of air for combustion devices in airtight houses. No one option appeared clearly more suitable in the opinion of a number of Canadian experts (14). The options considered were:

- isolate the combustion devices from the living space;
- provide a direct outdoor air supply for combustion air requirements;
- incorporate combustion air requirements into the design of the mechanical ventilation system of the house;
- install an induced draft fan in the flue stack and a flow proving device interlocked with the burner controls to ensure that downdrafting of the chimney cannot occur;

- ban combustion equipment from the inside house (use electricity for space and domestic hot water heating).

Heat Recovery

Heat recovery is the process of extracting heat energy from exhausted air and returning it to the interior of the house. If mechanical ventilation is used, heat recovery is possible via air-to-air heat exchangers or heat pumps. Air-to-air heat exchangers are normally used since exhaust air heat recovery heat pumps are currently not readily available.

Heat exchangers transfer heat energy from one flow of gas or liquid to another. The degree to which they are successful in doing this is called the effectiveness, and is the ratio of actual heat transferred to the maximum possible heat transfer. Heat exchangers have a surface to extract heat from the hot liquid or gas flow, a transfer medium and a surface to return heat to the cold liquid or gas flow. If the hot and cold flows can be brought close together, then the transfer medium can be the material separating the flows.

Current practice favours the plate type air-to-air heat exchanger for cost, ease of maintenance and simplicity reasons. Quoted effectiveness lies in the range of 0.50 - 0.80 (11,19,20,21). Factors affecting performance include the ratio of mass flow rates, condensation, air leakage, and deposits on or corrosion of heat exchange surfaces. A detailed study of air-to-air heat exchangers can be found in reference (11).

Filters are usually installed where air enters the heat exchanger on both the fresh air and exhaust sides in order to prevent accumulation of dust and other foreign matter on the heat transfer surfaces. The fresh air supply and the exhaust air outlet to outside should be installed on the same wall of the house, not closer together than 1 metre and not too close to corners. These precautions are necessary to ensure that the inlet and exhaust vents are exposed to the same exterior pressure. If they were installed on different walls or near corners, local wind effects could cause pressure differences between the two vents, upsetting the balance of the system.

Placing the vents too close together on the same wall could result in short-circuiting, where a large part of the exhaust air is brought indoors by the fresh air supply vent.

Air Filtration

Air cleaners are provided in most forced air systems to remove particulates. However, there are many other different types of cleaners suitable for residential use. These may become more important as the quality of outside air decreases or the amount of air recirculated within the house increases. Air cleaners can only partially remove contaminants so ventilation must be provided to eliminate the remainder.

There is no one type of air cleaner that can control all types of contaminants, so the choice of which type or types to use will depend on which contaminants are to be controlled. The ideal system would combine low cost, simplicity, and low maintenance costs with low energy requirements. Little work has been done on such systems for the residential market and no standards exist for their performance, although ASHRAE does have a standard for mass and size efficiencies of individual filters. References (22) and (23) give further information on characteristics of most types of air cleaners.

Dehumidifiers

Using dehumidifiers to control humidity would allow a minimum ventilation rate to be selected on the basis of factors other than moisture control. Since experience with energy-efficient housing has shown that humidity is often the factor that determines ventilation requirements, it is likely that a lowered ventilation rate would be possible in a house equipped with a dehumidifier. The extent to which the ventilation rate could be lowered is limited by the fact that presently available dehumidifiers are only able to reduce moisture levels to 50 per cent relative humidity (24).

Controllers

The possibilities offered by automatic control of ventilation rates have not been explored in depth in recent housing. Automatic controls could offer infinitely variable or stepped control of ventilation rates with manual override to allow for unusual events such as large numbers of people in the house or for periods when the house is unoccupied. The

controlling element could be a humidistat, a differential pressure sensor, a contaminant level sensor or any combination of the above. A sophisticated humidity controller could include a humidistat, and exterior and interior temperature sensors, connected to and controlled by a microprocessor. Such a device could compensate for the fact that the minimum interior humidity level necessary to prevent condensation is dependent on interior and exterior temperatures.

Current Trends

For maximum energy efficiency, a mechanically ventilated house with a heat exchanger for heat recovery appears to be the best alternative. Further improvement could be obtained with a load-sensitive controller that regulates the ventilation rate according to the demand for fresh air. The payback period of most heat recovery devices (from 2 to 30 years depending on energy and equipment costs), however, is such that it is doubtful whether they could be justified purely on cost savings (11,20).

For mechanically ventilated houses, air-to-air heat exchangers of the flat plate type are almost always installed. In order not to create balancing problems, by using local exhaust fans, any kitchen or bathroom intake vents are ducted to the interior air intake of the heat exchanger. Special attention must be paid to the placement of the kitchen air intake so that it does not pick up grease particles, some of which would find their way to the heat exchanger, lowering its effectiveness. A recirculating range hood is then provided to remove grease. The warmed exterior air can be discharged through a single vent anywhere inside the house or into the furnace return air plenum. It has been found that a suitably located single discharge vent can give acceptable air distribution (25). Discharging into the furnace plenum can cause balancing problems. The cyclic operation of the furnace fan can upset the pressure balance and airflow in the heat exchanger.

The codes and standards reviewed in this section cover all aspects of ventilation. The ventilation requirements in these codes/standards cannot conveniently be subdivided into categories for air quality, combustion devices and competition between all air consuming devices.

National Building Code Residential Standards

In Canada, the two primary codes or standards which prescribe ventilation requirements for residential buildings are the National Building Code of Canada (26) and the Residential Standards (27). The National Building Code of Canada is essentially a set of minimum regulations respecting the safety of buildings with reference to public health, fire protection and structural sufficiency. It is an advisory code only, until legally adopted by a jurisdictional authority. In the past, the National Building Code of Canada has received extensive use through voluntary adoption by municipal governments. Most provincial governments and the two northern territories have adopted or are using the National Building Code as the basis for their own building codes. The residential provisions of Part 9 of the National Building Code of Canada, combined with additional requirements concerned with both quality and amenity, make up the Residential Standards. The requirements contained in Residential Standards are applied by Canada Mortgage and Housing Corporation to all residential construction under the National Housing Act and are used as a guide in other residential construction throughout Canada.

The National Building Code and the Residential Standards are essentially identical with respect to their requirements for ventilation of buildings for residential occupancy. They contain requirements for the ventilation of crawl spaces and roof spaces as well as requirements for ventilation of interior spaces by natural or mechanical means. The requirements for mechanical ventilation apply only to buildings that are not more than 3 storeys in building height, with a building area of not more than 600 m2 and where the rated fan capacity does not exceed 2,000 L/s. In general, the types of residential buildings which are under consideration in this report will not exceed these limits.

These documents require that rooms or spaces in buildings be ventilated by natural or by mechanical means. However, if a dwelling is heated with other than fuel-fired equipment within the dwelling, a

mechanical exhaust system of one or more fans or blowers having a total capacity of at least 50 L/s must be provided. In addition, a space that does contain a fuel-fired heating appliance must have a natural or mechanical means of supplying the required combustion air. Air contaminants released within the building must be removed, insofar as possible, at their points of origin and cannot be permitted to accumulate in unsafe concentrations.

In rooms or spaces in buildings ventilated by natural means, adequate ventilation is achieved by specifying a minimum unobstructed area to the outdoors for various types of rooms. Where rooms or spaces are mechanically ventilated, the system must be capable of providing at least 1 ach. The remainder of the requirements for mechanical ventilation deal mainly with the design and installation of ducts, air intakes and exhaust outlets.

Ontario Building Code

Most provincial governments have adopted or are using the National Building Code as the basis for their own building codes. As an example, in Ontario, the Ontario Building Code (28) is based on the National Building Code and applied throughout the province to all new construction and to all substantial alterations or repairs to existing buildings. Its requirements for ventilation of residential buildings are almost identical to the National Building Code except that, in mechanically ventilated washrooms, there must be an exhaust air flow rate of 25 L/s per sanitary fixture. However, a proposed addition to the Ontario Building Code would require mechanical ventilation systems, in new, single family dwellings, to provide a minimum ventilation rate of 0.5 ach. This requirement would be optional and at the discretion of the designer. However, if such a mechanical system is used, it would have to be designed by a professional engineer. This addition is expected to be incorporated in the code before the end of 1983 (29).

"Measures for Energy Conservation in New Buildings"

The Associate Committee on the National Building Code has issued a document entitled "Measures for Energy Conservation in New Buildings" (30), which is aimed at providing a basis for controlling energy consumption in new buildings. This document has been prepared using the Amercian Society of Heating, Refrigerating

and Air-Conditioning Engineers (ASHRAE) Standard 90-75 (31) as a guide, but contains modifications to adapt the requirements to Canadian conditions. These measures are intended to provide a basis for improving the energy use characteristics of new buildings and are intended for use either as a guide or as the basis for regulatory requirements for the design of new buildings (30). The 1978 edition of "Measures for Energy Conservation in New Buildings" will be replaced by a 1983 edition due for publication before the end of 1983. This new edition will contain ventilation rate requirements based on ASHRAE Standard 62-1981 (32).

In the United States (and in Canada), the standards and publications issued by the Amercian Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) are widely quoted in building codes and are used extensively in the design of ventilation systems. The current ASHRAE standard concerning ventilation requirements is Standard 62-1981 "Ventilation for Acceptable Indoor Air Quality" which replaces previous ASHRAE ventilation standards.

ASHRAE Standard 62-1981

Standard 62-1981 specifies two alternate procedures to obtain acceptable indoor air quality. The Ventilation Rate Procedure prescribes the rate at which ventilation air must be delivered to a space and various means to condition that air. The ventilation rates shown in Table 6.1 are for residential facilities and are derived from "physiological considerations, subjective evaluations and professional judgements" (33).

Table 6.1 Ventilation Requirements from ASHRAE 62-1981

Area	L/s per room	
General living areas	5	
Bedrooms	5	
All other rooms	5	
Kitchens	50	Installed capacity for
Baths, toilets	25	intermittent use.

The ventilation rates shown in Table 6.1 are per room regardless of the size of the room. If proper air cleaners and adequate temperature control are provided, part of the ventilation air may be recirculated but the outdoor air portion must never be less than 2.5 L/s per person.

The alternate Indoor Air Quality Procedure specifies maximum permissible concentrations of certain notable contaminants in indoor air but does not prescribe ventilation rates or air treatment methods.

Nordic Committee for Building Codes

In 1981, the Nordic Committee for Building Codes (NKB) issued guidelines for minimum ventilation rates for buildings (2). In principle, these guidelines will be included in the national building codes of the five Nordic countries. The various ventilation rates are summarized in Table 6.2.

Table 6.2 NKB Minimum Ventilation Requirements

	Outdoor Air	Exhaust Air	Supplementary Ventilation
Dwelling as a whole	0.5 ach		
Bedroom	0.5 ach 4 L/s per person		Operable window
Living room	0.5 ach		Operable window
Kitchen		10 L/s	Operable window and range hood (30-100 L/s)
Bath		10 L/s	Operable window or adjustable ventilator with capacity of 30 L/s
Toilet		10 L/s	

To fulfill these requirements, as well as requirements regarding energy conservation, some kind of mechanical ventilation is needed, either an exhaust system with exhaust air terminal devices in every bedroom as well as in the kitchen and bathroom or by a combined supply and exhaust system (2).

Swedish Building Code

The 1980 Swedish Building Code (34) lists detailed requirements for airtightness of the building, air flow rates, air quality and energy conservation. In general, the philosophy appears to be that maximum air tightness should be obtained and that ventilation should then be accomplished using a controlled ventilation system to achieve an acceptable air quality within the building.

For residential buildings a minimum air change rate of 0.35 L/s per m2 of floor area is specified. For dwellings with normal ceiling heights, this corresponds to approximately 0.5 ach. Minimum exhaust air flow rates are also specified for certain rooms, as shown in Table 6.3.

Table 6.3 Swedish Code Minimum Exhaust Rates

Premises	Minimum Exhaust Air Flow Rate
Kitchen with more than 2 burners	exhaust fan capable of a minimum of 30 L/s
Kitchenette, pantry, 1 or 2 burners	15 L/s
Bathroom	10 L/s + 1 L/s for each m2 of floor area over 5 m2 (if no window, exhaust fan capable of a minimum of 30 L/s is needed)
Laundry room, drying room, recreation room	10 L/s + 1 L/s for each m2 floor area over 5 m2
Separate water closet room	10 L/s

Single family dwellings may use natural or mechanical ventilation but any other residential buildings must use mechanical ventilation. Energy conservation is addressed by specifying, in addition to air tightness and ventilation rates, minimum values for insulation as well as requiring heat recovery devices in large dwelling homes, when the heat content of the exit air exceeds that of the make-up air by more than 50 MWh/year during the heating season. In practice, this difference is much larger than is ever experienced in single family dwellings.

Air Quality Standards

This section of the report has presented a summary of current codes and standards related to ventilation requirements for residential buildings. The various ventilation rates specified in these codes and standards have been presented. No attempt has been made to present current codes and standards related to indoor and outdoor air quality. However, many ventilation standards (such as ASHRAE 62-1981) now require outdoor air to be of a specified acceptable quality before it is used for ventilation, and allow

recirculation and/or treatment of indoor air as long as certain air quality standards are met. Thus, ventilation requirements are implicity related to air quality codes and standards. The reader is referred to ASHRAE Standard 62-1981 for further analysis of the subject and to references (22) and (35) for comprehensive summaries of North American and international air quality standards.

Other Guidelines

In addition to the Canadian codes and standards previously described, there are a number of Canadian housing programs which have specific guidelines relating to ventilation. These programs include the Home Energy Loan Program (HELP), the R-2000 Program and programs sponsored by the Ontario Ministry of Energy and the Canadian Electrical Association. The latter three programs require ventilation rates of 0.5 ach (13).

This section presents current work in the field of ventilation research and related fields. Recently completed work is also mentioned.

Energy Conservation and Oil Substitution Branch Energy, Mines and Resources Canada

Energy, Mines and Resources Canada, through the Buildings Energy Technology Transfer (BETT) Program, is promoting the widespread adoption of energy conservation in the various building sectors by providing technological information to the appropriate end users.

In terms of ventilation research, EMR has been doing cooperative work with CMHC, HUDAC, Health and Welfare Canada and other government agencies. Details of the work can be found later in this section under their respective headings.

As part of the BETT Program, the Ontario Research Foundation (ORF) is preparing a report, with the title "Combustion Air Requirements for Airtight Homes" (14), for Energy, Mines and Resources Canada. This report estimates the amount of air required for various combustion requirements and discusses alternatives for the supply of combustion air. ORF is also preparing two other reports, entitled "Air-to-Air Heat Exchangers (ATAHE) for Airtight Homes: A Technical Background Paper" and "A Review of Current Mobile Home Standards Covering Fuel-Burning Appliances to Assess Their Applicability to Airtight Homes". These three ORF reports are currently in draft form (13).

EMR is working on a proposal for a Northern Housing energy efficiency standard. A technical committee with a working group composed of representatives from Indian and Northern Affairs, CMHC and NRC is preparing a draft standard. At the time of writing of this report, the more important points are that the building envelope is to be made as airtight as possible and 0.5 ach has been adopted as a basic ventilation rate using either natural or mechanical ventilation systems (36). There are many factors unique to northern housing including the high cost of electricity and building materials which impose different constraints on housing design than those in a more temperate climate. This proposed standard is currently in the draft stage.

Technical Services Branch
Indian and Nothern Affairs Canada

An experiment is currently being conducted in Frobisher Bay to examine the effectiveness of an air-to-air heat exchanger under northern conditions. An Air Changer Company full counterflow, plastic heat exchanger is being used. This experiment has been underway since February 1983 and is expected to continue for an indefinite period. Initial results indicate a wide variation in effectiveness (36).

Division of Building Research
National Research Council

A study is currently underway monitoring formaldehyde, radon and radon daughter levels in eight houses in Ottawa, using grab sampling and dosimeters. Also being measured are temperature, inside and outside relative humidity, windspeed and direction, and infiltration using the tracer gas technique. The monitoring frequency is once per week. No results are currently available (37).

"Mechanical and Passive Ventilation" is the title of a recently completed but not yet published paper. In it, balanced and fan exhaust mechanical ventilation systems are compared using varying air change rates and changing weather conditions in a test house (38).

Forty-five low energy use houses in Saskatchewan are being surveyed for air quality. Formaldehyde, radon, nitrogen dioxide and humidity levels are being monitored. Fan pressurization and tracer gas tests will be performed on all houses. The monitoring portion of this work will be completed in April 1983 and the paper will be published some time in 1984 (39).

"A Study to Determine Contaminant Build-up in Houses" by MacLaren Engineers was completed in April 1982. Radon and formaldehyde levels were measured in 18 detached single family houses in the Toronto area that were known to be relatively air-tight. Fan pressurization tests and tracer gas measurements were performed on the houses with varying weather conditions. A correlation was found between windspeeds and infiltration rates, and inside-outside temperature differentials and infiltration rates. Formaldehyde levels were up to 0.058 ppm. Radon daughter levels had a high average of 0.0037 WL. These levels appeared to vary approximately as the infiltration rate varied (40).

The possibilities for a CO2 controlled outdoor air supply are currently being investigated. Since the cost of such systems is expected to be higher than the residential market will tolerate, the primary area of application for this research is in office buildings. This project was initiated recently and will require several years for completion (41).

Technical Research Division
Canada Mortgage and Housing Corporation

A recently completed study entitled "Indoor Air Pollution and Housing Technology" by Small and Associates reviews current scientific knowledge on indoor air pollution and looks at the special needs of the small percentage of the population that are more sensitive to indoor pollutants than the population at large (42).

"Hazardous Heating and Ventilating Conditions in Housing" is an across-Canada survey funded by the Canada Mortgage and Housing Corporation, Energy Mines and Resources, and Health and Welfare. This study examines episodes from up to 10 years ago, where combustion products have been detected in excessive levels. The report is due to be published in April 1983 (42).

"Review of Existing Instrumentation and Evaluation of Possibilities for Research and Development of Instrumentation to Determine Future Levels of Radon at a Building Site", recently published, was managed by the Atomic Energy Control Board and funded by Canada Mortgage and Housing Corporation, Atomic Energy Control Board and the National Research Council. It looks at methods available for measuring levels of radon at existing sites to determine if it is a suitable building site and concludes that instrumentation and methods are available (42).

"Air-to-Air Heat Exchangers" by the ECE Group and the Ontario Research Foundation for the Canada Mortgage and Housing Corporation, Energy Mines and Resources and the Housing and Urban Development Association of Canada, was released in June 1982.

It surveys the presently available heat exchangers and considers operational requirements such as maintenance, controls, and defrosting. The integration of heat exchangers into the ventilation

system and test methods to evaluate performance are also discussed (11).

"Performance Evaluation of the Apple Hill Energy Efficient Houses" by Co-generation and Associates for Canada Mortgage and Housing Corporation and Energy Mines and Resources is expected in final form in June 1983. Thirty houses in Kanata are being monitored for air-tightness, neutral pressure plane position, inside and outside temperatures, relative humidity, wind speed and air quality (formaldehyde, carbon monoxide, carbon dioxide, oxides of nitrogen, radon) at three month intervals. In most of these houses, the furnace room is of the inside-outside type (in the basement in a sealed room). Originally the objective of this project was to monitor the energy performance of these houses, but this has now been expanded to include the interaction of the parameters listed above. Other than the finding that it has been difficult to seal the furnace rooms using conventional construction techniques, interim results are not yet available (42).

Two houses in Cape Dorset using Air Changer Company heat exchangers are instrumented to measure effectiveness in a similar experiment to that described earlier in this section (36,42).

"Moisture Induced Problems in NHA Housing" is a three-part study scheduled for release at the end of April 1983. Phase I is a survey of reported moisture troubled homes. Phase II is a literature review and Phase III is titled "Applicable Moisture Reduction Techniques for Newfoundland". This is a theoretical discussion of how to employ existing technology to reduce moisture. Also, a monitoring program has been recently completed in St. Johns, Newfoundland, to determine the effectiveness of stack vents and dehumidifiers in reducing humidity. This program, with T E S Limited as instrumentation consultants, monitored interior and exterior temperature and humidity levels, and neutral pressure plane position for three months (24).

Ontario Ministry of Energy

The Conservation Group, through the Canada/Ontario Conservation and Renewable Energy Demonstration Program, is testing the effectiveness of three ventilation techniques in an energy-efficient housing

co-operative in Toronto. The first system employs conventional manually controlled fans in the kitchen and bathroom. The second system employs dehumidistat control on the exhaust fans and the third system uses air-to-air heat exchangers. Interior temperature and relative humidity, energy use and fan usage are being recorded continuously. An interim report is expected in several months (43).

In the planning stage is a project between the Ministry of Energy, Consumers Gas and the University of Toronto to measure air quality and combustion air requirements of homes before and after improving air tightness (43).

HUDAC

"Guidelines for the Design and Installation of Residential Controlled Ventilation Systems" by the IBI Group was prepared for the Canada Mortgage and Housing Corporation and the Housing and Urban Development Association of Canada. It uses the ASHRAE standard 62-1981 as a principal standard and assumes a house with a high degree of air tightness. The main recommendations include using a mechanical ventilation system including kitchen and bathroom exhaust, a two speed furance fan, and allowing for the entry of air to match the total exhaust flow. This report is directed towards builders and contractors (12,42).

Canadian General Standards Board

The fifth draft of the standard "Determination of Airtightness by the Fan Depressurization Method" (149-GP-10M) is, at the time of writing, out for approval. It specifies fan sizes, calibration and test procedures, number and location of exterior pressure taps, and procedure for calculating correlation coefficients and equivalent leakage area (44).

A committee has been formed on means of detecting indoor pollutants. The first meeting was in November 1982 at which it was decided that more information was needed. This group will not be proposing allowable levels of contaminants (42,45).

Saskatchewan Research Council

There is currently no work underway in the area of residential ventilation requirements. Problems experienced in recent housing with respect to supplying combustion air requirements and possible

	air quality problems have led to plans being made for studies in these areas. Funding for these studies is currently being negotiated (46).
Department of Mechanical Engineering University of Saskatchewan	Work is planned starting in the summer of 1983 on frosting phenomena in air to air heat exchangers of the flat plate type. Instrumentation will measure any loss of efficiency, relative humidities and temperatures on the inlet and exhaust sides (47).
Health and Welfare Canada	The Federal-Provincial Working Group on Indoor Air Quality has a mandate to develop acceptable levels of CO, NO2, formaldehyde, other aldehydes, CO2, SO2, moisture, oxidants, polycyclic aromatic hydrocarbons (combustion products), radon, microbiological products, aerosols, asbestos, chlorinated hydrocarbons and lead. A report was scheduled for release in 1984 but will probably be behind schedule (45).
Department of Regional and Economic Expansion	"A Market Study of Residential Ventilation in Quebec and Ontario" by Major and Martin was released in January 1983 in French with an English summary. It looks at the growing market for residential ventilation systems and concludes that there is a significant market if the correct marketing strategy is followed (48).
Relevant Activities in the United States	A summary as of 1981 of government and industry activities is contained in chapter 5 of reference (35). Briefly, it states that the Department of Energy proposed revised Building Energy Performance Standards which were somewhat controversial in the area of indoor air quality. These were changed after input from other government agencies and industry associations.
University of California Lawrence Berkeley Laboratories	The Lawrence Berkeley Laboratory of the University of California has done the majority of the significant research in the United States in the field of ventilation for energy efficient housing under their "Building Ventilation and Indoor Air Quality Program". The main funding was provided by the Department of Energy. Areas of research since 1976 have included monitoring of various contaminant levels in energy efficient housing, development of instrumentation for these

measurements, performance measurements of residential air-to-air heat exchangers and retrofits to existing housing for energy conservation (49). They currently have no work underway in these areas (50).

ASHRAE

The standards published by ASHRAE are widely quoted and form the basis of many building codes. In particular, Standard 62-1981 "Ventilation for Acceptable Indoor Air Quality" (which contains significant revisions of the previous Standard 62-73) has widely used minimum ventilation rates.

Normally, these standards are revised on a three year schedule. The only revisions currently being considered for Standard 62-1981 are to further define the allowable levels of various contaminants to reflect information that was not available at the time of formulation of Standard 62-1981 (51).

Also in the formative stages are Standards Project Committees with the following purposes and scopes. Standards Project Committee 119 - "Air Leakage for Residential Buildings" will present design guidelines and specify the combined leakage of building components so the standard can be met without an air tightness test. Standards Projects Committee 90-1980/75R - "Energy Conservation in New Building Design" will specify design requirements for the improvement of energy utilization. At this time it is not known whether ventilation rates will be specified (51,52).

American Society for Testing Materials (ASTM)

The ASTM has recently issued two standards of interest concerning measurement of air leakage by fan pressurization and the tracer gas method. They estimate the uncertainty with both methods at 10% or less.

ASTM Standard E741-80 "Measuring Air Leakage by the Tracer Dilution Method" describes the apparatus, procedure and calculations to be followed when using the tracer gas method. Of note are that all weather conditions (temperature, wind speed, direction, barometric pressure) are recorded whenever a sample is taken and that a multi-point sampling network is used to draw air samples. Circulating fans are used to ensure complete mixing of the tracer gas and inside air (53).

ASTM Standard E779-81 "Measuring Air Leakage by the Fan Pressurization Method" specifies the apparatus, procedure and calculations for this method. Measurements of airflow rates are taken from 12.5 to 75 Pa with 12.5 Pa increments. It is advised that at wind speeds of over 16 km/h, the test should be halted. Corrections are applied for the stack effect in buildings with more than one story (53).

The International Energy Agency

The International Energy Agency was formed within the Organization for Economic Co-operation and Development in 1974 to strengthen cooperation in energy policy. Areas where knowledge was felt to be lacking included infiltration and minimum ventilation rates, among others. Annex V (The Air Infiltration Centre) and Annex IX (Minimum Ventilation Rates) were formed to address these needs.

Annex V, which is based in England and has Canada (representative - R. Dumont, NRC), Denmark, Italy, Netherlands, Sweden, Switzerland, United Kingdom and the United States as its participants, encourages co-ordinated international research by disseminating knowledge on infiltration and recommending directions for future research. Yearly conferences are held on selected topics and a constantly updated database, "Airbase" is maintained on published papers covering air infiltration and related subjects. Also a handbook entitled "Air Infiltration Control in Housing - A Guide to International Practice" is planned which will contain information on minimum acceptable ventilation rates and methods of achieving low air leakage (54).

Annex IX, has similar objectives to Annex V, that is, the collection and dissemination of relevant research and recommendations for future research. Participants include Canada (representative - G. Tamura, NRC), Switzerland, Germany, Denmark, Italy, Sweden and the United Kingdom. Report 1, a review of literature, standards and current research was published in August 1981. Report 2 identifying needs for and proposing future research has not yet been issued. However, each participant country has been assigned a specific mandate. Canada will be looking at ventilation requirements for CO2 (37,55).

In section 4 of the report, the various needs for ventilation were reviewed. From the information presented, it can be seen that a complex biological, chemical and physical mix of indoor air pollutants can exist within a residential building. The required ventilation rate to establish an acceptable indoor air quality is by no means certain and can be affected by many factors.

Ventilation Rates

The estimated ventilation rates required to control the various pollutants were presented. A ventilation rate of up to 50 L/s may be required to control products of combustion and humidity while an air change rate of 0.5 ach may be required for formaldehyde and radon control.

In order to relate these ventilation requirements, assume that an average sized house has a total volume ranging from 300 to 450 m3, then 0.5 ach is equivalent to approximately 40 to 60 L/s. Thus, it would appear that ventilation rates in the order of 50 L/s are likely to be required if all pollutants are to be controlled satisfactorily.

There appears to be a general belief that, for airtight houses in Canada during the winter, humidity is the indoor factor most likely to determine the required ventilation rate. However, humidity levels are drastically affected by occupant behaviour and moisture sources within the house. Thus, control of moisture in a low occupancy/usage house may require relatively low ventilation rates which might be insufficient to control site specific pollutants such as radon and formaldehyde.

Combustion Devices

As previously discussed, it appears that, in an airtight and energy efficient house, the air requirements of combustion devices can be incorporated into the design of a properly designed and balanced ventilation system for the house. The air requirement may be low (18 L/s) (14) compared to a ventilation rate of 50 L/s. However, if the ventilation rate is set at a lower level of 25 L/s, there could be a strong interaction between systems with an unpredictable and possibly dangerous outcome. Similarly, a failure in the house ventilation system or the creation of a negative pressure within the house (with respect to outdoor air), could result in the failure of the venting system for the combustion

device, and the release of toxic gases into the indoor environment. Obviously, such a scenario must be avoided. There are several solutions to this problem including isolating the combustion devices from the living space; providing a direct outdoor air supply for combustion air requirements; installing devices that will prevent chimney downdrafting; and banning combustion equipment from the interior of the house. These various options are discussed in detail in reference (14).

Mechanical Ventilation/ Heat Recovery

It appears certain that airtight houses must use mechanical ventilation in order to achieve adequate control of the ventilation rate. The possible layouts of such systems are relatively straightforward and can use existing ventilation equipment and components. However, the controllers currently used to operate mechanical ventilation systems in houses are, at best, simplistic. Although the mechanical equipment is available, control systems which are capable of optimizing ventilation rates to satisfy both air quality and energy conservation requirements, as well as provide warning of system malfunction or failure, are non-existent or in the preliminary development stages. The use of heat recovery devices may not be justifiable on a strictly economic basis. However, a "Super Energy Efficient" house without some means of recovering energy from the ventilation air would appear to be a contradiction in terms.

Codes and Standards

As previously discussed, a ventilation rate of approximately 50 L/s or 0.5 ach is required to control the air quality in a house. Currently, the National Building Code permits ventilation by natural or by mechanical means. Where a space is mechanically ventilated, the system must be capable of providing 1 ach. In addition, in a dwelling which is not heated by fuel-fired equipment, a mechanical exhaust system with a capacity of at least 50 L/s must be provided. However, there is no requirement to use the system.

ASHRAE Standard 62-1981 requires a ventilation rate based on the number of habitable rooms. A normal house might have between 8 and 10 such rooms and thus require a ventilation rate between 40 to 50 L/s. In addition, there must be an installed device in the kitchen with a capacity of 50 L/s for intermittent use. Both the Nordic Committee for Building Codes

and the Swedish Building Code specify a dwelling ventilation rate of 0.5 ach.

Thus, it appears that a general consensus has been reached that a ventilation rate of 0.5 ach (approximately 50 L/s) is required to maintain an adequate air quality level in residential buildings. This ventilation rate can be regarded as a justifiable minimum requirement for airtight houses in Canada.

Several basic questions must be answered before any specific recommendations can be made concerning a proposed new ventilation standard. Should the standard have energy efficiency as its main objective or should some account be taken of costs? Should the means to achieve a desired minimum air quality level and/or air tightness be specified? Should these standards be enforced in the design stage only, or should "as-built" tests be performed. Should the desired air quality level be expressed in terms of contaminant levels or a minimum ventilation rate? If a minimum ventilation rate is to be used, should it be based on volume, floor area, or number of occupants or rooms?

The basis of any new standard on ventilation rates should be the maintenance of acceptable indoor air quality. Only after this has been satisfactorily addressed can questions of energy efficiency, cost effectiveness and other considerations be addressed. It is recommended that methods of achieving this level of air quality (ventilation systems and rates) be given as suggestions only, in order to leave designers free to specify any system that will meet the air quality requirements. If energy efficiency is of prime importance, then a mechanical balanced ventilation system with heat recovery becomes the system of choice and should be specified. Some consideration should be given to incentives for heat recovery since the present economics involved do not provide a clear savings.

ASHRAE 62-1981

It appears that ASHRAE Standard 62-1981 could form the basis of a new ventilation standard. There are several advantages to using ASHRAE 62-1981. Firstly, the standard is quite comprehensive and considerable thought has gone into its formulation.

Secondly, ASHRAE standards are commonly used in Canada and a ventilation standard based on ASHRAE 62-1981 would likely be readily acceptable to mechanical designers across the country. Thirdly, the 1983 "Measures for Energy Conservation on New Buildings" will specify ventilation requirements based on ASHRAE 62-1981.

If a new ventilation standard is based on ASHRAE 62-1981, however, it must also take into account conditions specific to Canada (different air quality standards, climate, etc.) and the special requirements of airtight housing. Since existing ventilation standards in Canada are aimed at all types of housing they set minimum standards but are by no means comprehensive. The adoption of an extensive ventilation standard based on ASHRAE 62-1981 would help insure that indoor air quality problems are addressed in all future residential buildings.

Considerations

The following items should be considered in the development of the proposed standard for airtight houses in Canada:

- The development of a ventilation standard must be undertaken in concert with the establishment of complementary standards for building air tightness and indoor and outdoor air quality.
- The standard should require minimum ventilation rates of approximately 0.5 ach or 50 L/s with the capability to ventilate the dwelling to at least 1.0 ach for intermittent usage.
- Consideration should be given to mandating the use of mechanical ventilation systems, unless the use of such systems is impossible due to lack of a power source, or if a natural ventilation system can demonstrably be shown to achieve proper ventilation control and rates.
- The use of heat recovery devices must be considered. Such devices might only be required if the amount of energy lost in the exhaust air during the heating season exceeds a specified amount.
- The question of safety must be considered. The standard must address the problem of what happens when a ventilation system malfunctions or fails

completely. Similarly, methods for the fail-safe use of various combustion devices in airtight houses must either be provided or such devices banned.

- The ventilation system should not only have to meet certain standard criteria during the design stage, but should be "tuned and balanced" once the house is occupied. A suitable means of ensuring the proper operation of the system in future years should also be considered.

- Buildings may have to be tested to measure levels of certain contaminants such as radon and formaldehyde. Initial tests could be conducted when the air tightness of the building is measured. Further tests could take place when the ventilation system is tested and balanced. If high levels of toxic contaminants are found, then the ventilation rate may have to be increased and future contaminant testing conducted.

- The occupants of any airtight home should be supplied with an "owner's manual" which provides comprehensive information on the heating, ventilating and cooling systems in the house. The manual could include equipment specifications and sources, set-points, operating instructions and basic background information on energy conservation and ventilation requirements.

The main conclusions resulting from this review of ventilation requirements for airtight houses in Canada are, as follows:

- A general consensus has been reached that a ventilation rate of 0.5 ach (approximately 50 L/s) is required to maintain an adequate indoor air quality level.

- In order to achieve specified control of the ventilation rate, mechanical ventilation systems (possibly in conjunction with heat recovery devices) will likely be required.

- If combustion devices are located inside the house, then the ventilation system will likely have to be separate from the combustion air and draft air supply.

- ASHRAE Standard 62-1981 "Ventilation for Acceptable Indoor Air Quality" could form the basis of a new ventilation standard.

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Author(s)	A.D. Kent
Publisher/Date/Pages	NRC/1979/4 pages
Available from/Price	Division of Building Research National Research Council of Canada Montreal Road, Ottawa, Ontario K1A 0R6
Catalogue & Indexing Numbers	Canadian Building Digest 207 October 1979
Key Words	Ventilation requirements/air contaminants/oxygen depletion/fuel-fired appliances
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

The article outlines the effects of increased levels of carbon monoxide and carbon dioxide in poorly ventilated spaces where there is reduced oxygen content. A method for determining ventilation requirements for specific quantities of toxic gas production is included.

Critique

This article summarizes the short-term health effects of various combustion products. Useful ventilation rates to control various contaminants are quoted.

* Note: Not all references are included in this annotated bibliography.

BIBLIOGRAPHY (Reference 2)

Title	"Guidelines for Nordic Building Regulations Regarding Indoor Air Quality"
Author(s)	J. Sundell
Publisher/Date/Pages	Environment International/1982/4 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario $0.88 (photocopy)
Catalogue & Indexing Numbers	TD 172 E55 Environment International Vol. 8, pp 17 - 20, 1982
Key Words	Energy conservation/mechanical ventilation/indoor air quality/building codes
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

These guidelines provide and discuss acceptable outdoor air quality for ventilation and minimum outdoor air flows in dwellings and offices. The guidelines serve as a basis for designing energy-efficient buildings which will maintain comfortable and safe indoor air quality.

Critique

This paper is a most useful summary of Nordic building codes.

BIBLIOGRAPHY (Reference 3)

Title	Code of Practice for Design of Buildings: Ventilation and Designing for Natural Ventilation
Author(s)	British Standards Institution
Publisher/Date/Pages	BSI/1980/24 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $6.16 (photocopy)
Catalogue & Indexing Numbers	SER T4 B86 Code Number BS 5925:1980
Key Words	Natural ventilation/air flow rates/building design/building regulations
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This code of practice gives recommendations for the supply of outside air and outlines the building procedures required to implement these recommendations. It includes a bibliography and references to publications.

Critique

This code contains useful design data on weather and temperature effects as well as formulas for the determination of natural ventilation rates.

BIBLIOGRAPHY (Reference 4)

Title	"Energy Savings Due to Changes in Design of Ventilation and Air Flow Systems"
Author(s)	F.W. Hutchinson
Publisher/Date/Pages	Elsevier Sequoia S.A.,/1977/8 pages Lausanne
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $1.76 (photocopy)
Catalogue & Indexing Numbers	NA 2542.3 E56 Energy and Buildings Vol. 1, no. 1, pp 69 - 76, 1977
Key Words	Energy conservation/ventilation systems/building design/outside air requirements/odour control/ effective temperature
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

Air distribution systems and sub-systems are analysed in terms of minimum energy requirements in this paper. The procedures for the design of ventilation and air flow systems are shown to be energy wasteful due to the methodologies and data bases used. Outside air requirements to control body odour are discussed. A comparison is made between the old and new ASHRAE definitions of effective temperature.

Critique

This paper looks at the control of body odour in detail.

BIBLIOGRAPHY (Reference 5)

Title	"Indoor Air Pollution and Its Effects on Health"
Author(s)	R.J.W. Melia et al
Publisher/Date/Pages	Royal Society of Health/1981/4 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $0.88 (photocopy)
Catalogue & Indexing Numbers	SER RA 393 R88 Royal Society of Health Journal, vol. 101 no. 1, 1981
Key Words	Indoor air pollutants/pollution level guidelines/respiratory illness/gas cooking/tobacco smoke/reduced ventilation rates/tables
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This paper summarizes recent changes in air pollutants, their sources, and their potential effects on health. It reiterates the difficulty faced in standardizing guidelines for the control of indoor air pollution and discusses the relationship between gas cooking and respiratory illness in children as reported in several studies.

Critique

This paper looks at the effects of gas cooking in detail.

BIBLIOGRAPHY (Reference 6)

Title	"Indoor Air Pollution"
Author(s)	J.L. Repace
Publisher/Date/Pages	Environment International Pergamon Press Ltd./1982/16 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $3.52 (photocopy)
Catalogue & Indexing Numbers	TD 172 E55 Environment International Vol. 8, pp 21 - 36, 1982
Key Words	Ventilation/indoor pollutants/product standards/ building codes/automatic ventilation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract	This paper discusses the nature of the problem of indoor air pollution, limitations in the authority of established health agencies to control the problem, research needs and control options.
Critique	This paper contains useful references to and excerpts from recent studies of specific contaminants.

BIBLIOGRAPHY (Reference 7)

Title	"Impact of Reduced Infiltration and Ventilation on Indoor Air Quality"
Author(s)	C.D. Hollowell, J.V. Berk and G.W. Traynor
Publisher/Date/Pages	ASHRAE Journal/1979/ 5 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $1.10 (photocopy)
Catalogue & Indexing Numbers	Ser TP490 A11 Vol 21 no. 7, pp 49 - 53
Key Words	Indoor air quality/contaminant levels/energy conservation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This report focuses on preventing increased health risks due to indoor air contaminants with an increase in energy conservation methods in residences. Two regulatory approaches and several design features are suggested.

Critique

Useful and detailed information on formaldehyde, radon and gas stove emissions is presented.

BIBLIOGRAPHY (Reference 8)

Title	"Position Statement on Indoor Air Quality"
Author(s)	ASHRAE
Publisher/Date/Pages	ASHRAE/1982/7 pages
Available from/Price	ASHRAE International Headquarters 1791 Tullie Circle, N.E. Atlanta, Georgia 30329
Catalogue & Indexing Numbers	Position Statement July 1, 1982
Key Words	Indoor air quality/energy conservation/mechanical ventilation/air contaminants/control methods
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This position statement applies to the improvement of occupied indoor environments; it aims to define air contaminant problems, energy requirements, trends in ventilation and materials used indoors, principles of control, and recommendations to government and industry for the development of solutions.

Critique

In this paper, ASHRAE states that government must take a leadership role in research on air qaulity. Some background material on the requirements for ventilation is presented.

BIBLIOGRAPHY (Reference 9)

Title	A Review of Ventilation Requirements for Residential Buildings in Canada
Author(s)	T E S Limited
Publisher/Date/Pages	CMHC/1980/45 pages
Available from/Price	Technical Research Division Canada Mortgage and Housing Corporation Montreal Road, Ottawa, Ontario K1A 0P7
Catalogue & Indexing Numbers	CMHC File Number 176-4-1
Key Words	Energy conservation/natural and mechanical ventilation/building codes and standards
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This review lists the needs for ventilation, the applicable codes and standards, the methods of ventilating houses according to codes, and assesses the current state of ventilation and how it applies to the construction of new and retrofitted residences.

Critique

This is a comprehensive review of ventilation requirements as of 1980.

BIBLIOGRAPHY (Reference 10)

Title	"Radon Measurements In 12,000 Swedish Homes"
Authors	O. Hildingson
Publisher/Date/Pages	Environment International Pergamon Press Ltd./1982/4 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $0.88 (photocopy)
Catalogue & Indexing Numbers	TD 172 E55 Environment International Vol. 8, pp 67 - 70, 1982
Key Words	Radon daughter levels/measurement methods/building materials
Sector Applicability	Office Residential Restaurant Industrial Retail

Abstract

This research paper describes measurement techniques and results from measurements of radon daughter levels in Swedish dwellings, and the present state of government limits. Radon exhalation from the ground and exhalation from building materials were found to be the two main sources of high indoor radon concentration.

Critique

This paper contains a useful graph of radon concentration vs. air change rate.

BIBLIOGRAPHY (Reference 11)

Title	Air-to-Air Heat Exchangers
Author(s)	The ECE Group Consulting Engineers and The Ontario Research Foundation
Publisher/Date/Pages	CMHC/1982/111 pages
Available from/Price	Technical Research Division Canada Mortgage and Housing Corporation Montreal Road, Ottawa, Ontario K1A 0P7
Catalogue & Indexing Numbers	CMHC Air-to-Air Heat Exchangers June 1982
Key Words	Heat exchangers/energy conservation/moisture and contaminant control
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This report provides an overview of the requirements for Air-to-Air Heat Recovery Devices for Canadian Housing. It includes performance requirements, frost protection effectiveness, cost effectiveness, and discusses the use of heat exchangers to maintain a negative pressure within a house envelope. Testing procedures, test facility requirements and appropriate testing organizations are listed.

Critique

This report is an excellent introduction to residential heat exchangers.

BIBLIOGRAPHY (Reference 12)

Title	Guidelines for the Design and Installation of Residential Controlled Ventilation Systems: Summary
Author(s)	IBI Group
Publisher/Date/Pages	HUDAC/1983/8 pages
Available from/Price	Housing and Urban Development Association of Canada 969 Bronson Ave. Ottawa, Ontario K1S 4G8
Catalogue & Indexing Numbers	Summary-Preliminary Report IBI Group February 6, 1983
Key Words	Ventilation requirements/building guidelines/mechanical ventilation systems/heat recovery
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This is a summary of the HUDAC guidelines which provide advice to builders on how to ensure adequate ventilation in tightly designed new houses. The guidelines consist of information on ventilation requirements, recommended systems, testing, operation and maintenance, heat recovery and on related reading material.

Critique

At the time of writing, this report was available in summary form only.

BIBLIOGRAPHY (Reference 14)

Title	Combustion Air Requirements for Well Sealed Homes
Author(s)	Ontario Research Foundation
Publisher/Date/Pages	Ontario Research Foundation/1983/26 pages
Available from/Price	Ontario Research Foundation Sheridan Park, Mississauga, Ontario L5K 1B3
Catalogue & Indexing Numbers	Task 3.1 Preliminary Report February 1983
Key Words	Combustion appliances/tightly sealed houses/ mechanical ventilation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This report presents and summarizes the opinions of various Canadian experts on the problem of supplying air for combustion appliances such as fuel-fired furnaces and domestic hot water heaters in homes with low natural air infiltration.

Critique

All available options for the supply of combustion air are explored but no consensus of opinion was reached by the experts.

BIBLIOGRAPHY (Reference 15)

Title	Effect of a Gas Furnace Chimney on the Air Leakage Characteristic of a Two-Storey Detached House
Author(s)	C.Y. Shaw and W.C. Brown
Publisher/Date/Pages	NRC/1982/7 pages
Available from/Price	Division of Building Research National Research Council of Canada Montreal Road, Ottawa, Ontario K1A 0R6
Catalogue & Indexing Numbers	Building Research Note No. 192
Key Words	Air infiltration rates/natural gas furnaces/electric furnaces/gas furnace chimney
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

The objectives of this study were to determine the influence of a gas furnace chimney on air tightness and air infiltration, the influence of various operating modes of a gas furnace, and the combined influence of weather and a gas chimney on air infiltration. The air infiltration rate was found to be greater with a gas furnace than with an electric furnace.

Critique

Although the data obtained is only for one specific house, the trends found are applicable to most houses.

BIBLIOGRAPHY (Reference 16)

Title	Air Tightness Measurements of Detached Houses In the Saskatoon Area
Author(s)	R.S. Dumont, H.W. Orr and D.A. Figley
Publisher/Date/Pages	NRC/1981/6 pages
Available from/Price	Division of Building Research National Research Council of Canada Montreal Road, Ottawa, Ontario K1A 0R6
Catalogue & Indexing Numbers	Building Research Note No. 178
Key Words	Air tightness/construction methods/low-energy houses
Sector Applicability	Office Residential Restaurant Industrial Retail

Abstract

The purpose of this study was to identify the air tightness levels of a group of houses in the Saskatoon area according to different ages, construction styles, and methods of achieving air tightness. The test results were also compared to a similar study of houses in the Ottawa area.

Critique

This study contains very useful data on air tightness measurements of a range of typical Canadian houses. This is useful for modelling leakage characteristics of houses.

BIBLIOGRAPHY (Reference 17)

Title	Natural Ventilation In the UK and Some Considerations for Energy Efficient Design
Author(s)	D.W. Etheridge
Publisher/Date/Pages	Air Infiltration Centre/1982/24 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $5.50 (photocopy)
Catalogue & Indexing Numbers	SER TH 7678 A88: 3rd AIC Conference, Sept. 1982: Paper B
Key Words	Natural and mechanical ventilation/energy conservation/building design/thermal insulation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This paper is a discussion of the potential for achieving an energy efficient natural ventilation system by improving design procedures. It reviews ventilation requirements, and compares natural and mechanical systems in terms of energy efficiency and cost effectiveness.

Critique

This paper contains useful information for designers of natural ventilation systems taking into account weather and occupant habits.

BIBLIOGRAPHY (Reference 18)

Title	Results of Air-Change-Rate Measurements in Swiss Residential Buildings
Author(s)	P. Hartmann, I. Pfiffner and S. Bargetzi Translation by Robert Serre
Publisher/Date/Pages	NRC/1980/13 pages
Available from/Price	Division of Building Research National Research Council of Canada Montreal Road, Ottawa, Ontario K1A OR6
Catalogue & Indexing Numbers	NRC Technical Translation TT - 1945 Ki Klima Kalte Ingenieur, Sonderdruck, (3): 95-99, 1978
Key Words	Air change rate/natural ventilation/tracer gas measurements
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract	This paper reports the results of some studies that were conducted in Switzerland on air change rate in small apartment buildings with open windows, using a tracer gas technique.
Critique	This is one of the few papers available that looks at occupant effects on ventilation rates.

BIBLIOGRAPHY (Reference 19)

Title	Test Results and Methods: Residential Air-to-Air Heat Exchangers for Maintaining Indoor Air Quality and Saving Energy
Author(s)	W.J. Fisk, et al
Publisher/Date/Pages	Lawrence Berkeley Laboratory/1981/17 pages
Available from/Price	National Technical Information Service Springfield, Virginia, U.S.A. 22161 $7.00 (U.S.)
Catalogue & Indexing Numbers	LBL-12280 EEB - Vent 81 - 6
Key Words	Heat exchangers/mechanical ventilation/energy efficiency
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

The aim of this report is to describe the results from performance tests of five commercially available air-to-air heat exchangers used in residential mechanical ventilation systems. It includes background information on the design and installation of heat exchangers, the LBL test facility and the test procedures.

Critique

Some of the heat exchangers tested may not be available in Canada.

BIBLIOGRAPHY (Reference 20)

Title	Efficiency of Air-to-Air Heat Exchangers In Occupied Houses
Author(s)	A. Svensson
Publisher/Date/Pages	Air Infiltration Centre/1982/11 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $2.64 (photocopy)
Catalogue & Indexing Numbers	Ser TH 7678 A88 3rd AIC Conference: Sept. 1982: Paper 19
Key Words	Heat exchangers/occupied residences/energy conservation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

The purpose of this project was to determine the energy savings obtained in the operation of a fan-controlled supply and exhaust ventilation system with heat recovery (an FTX-system) to an exhaust system controlled soley by a fan (an F-system) in residences.

Critique

This is a most useful paper that works with data obtained under actual living conditions and projects energy savings.

BIBLIOGRAPHY (Reference 21)

Title	Effectiveness and Pressure Drop Characteristics of Various Types of Air-to-Air Energy Recovery Systems
Author(s)	G.J. Gudac et al
Publisher/Date/Pages	ASHRAE Transactions/1981/12 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $2.64 (photocopy)
Catalogue & Indexing Numbers	SER TH 7201 A53 t 7 ASHRAE No. 2623 RP-173
Key Words	Energy recovery systems/heat exchangers
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This work presents the results of applying the methodology of ASHRAE Standard 84-78 in determi ng the performance of four types of devices: 1) coil energy recovery loop system 2) heat pipe heat exchanger 3) fixed plate exchanger and 4) the twin-tower enthalpy recovery loop system.

Critique

Although some of the energy recovery systems are not appropriate for residential use, useful performance and effectiveness curves are presented.

BIBLIOGRAPHY (Reference 22)

Title	Indoor Pollutants
Author(s)	National Research Council (Washington, D.C.)
Publisher/Date/Pages	National Academy Press/1981/66 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $14.74 (photocopy)
Catalogue & Indexing Numbers	TD 194.5 N277
Key Words	Indoor pollutants/building codes and standards/air quality/indoor environmental control
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This report was produced by the Committee on Indoor Pollutants. Relevant chapters cover applicable building codes and standards, the types and performance of air cleaners and the various strategies for control of indoor pollution.

Critique

This report is a very comprehensive document. The section on air cleaners is especially thorough, although the discussion of codes and standards is limited in scope to the United States.

BIBLIOGRAPHY (Reference 23)

Title	"Methods For Control of Indoor Air Quality"
Author(s)	C.E. Billings and S.F. Vanderslice
Publisher/Date/Pages	Environment International Pergamon Press Ltd/ 1982/8 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $1.76 (photocopy)
Catalogue & Indexing Numbers	TD 172 E 55 Environment International Vol. 8, pp 497 - 504, 1982
Key Words	Indoor air quality/pollutant exposure levels/ ventilation systems/air cleaners
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This report presents results of a review of available methods for control of environmental hazards applied to indoor air pollutants. Alternative methods available to control indoor air pollutants exposures are identified, the performance characteristics of ventilation systems and of air cleaning devices are described and results of previous confined-space studies are reviewed.

Critique

This report has a comprehensive section on air cleaners and also looks at recirculating ventilating systems.

BIBLIOGRAPHY (Reference 25)

Title	Residential Ventilation With Heat Recovery: Improving Indoor Air Quality and Saving Energy
Author(s)	G.D. Roseme, et al
Publisher/Date/Pages	Lawrence Berkeley Laboratory/1980/27 pages
Available from/Price	National Technical Information Service Springfield, Virginia, U.S.A. 22161 $8.50 (U.S.)
Catalogue & Indexing Numbers	LBL-9749 EEB - Vent - 80 - 10
Key Words	Air quality/mechanical ventilation/air-to-air heat exchangers/indoor pollutants/energy conservation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This paper reports residential air quality measurements conducted by Lawrence Berkeley Laboratory. It discusses the use of mechanical ventilation systems with air-to-air heat exchangers as a potential means of pollutant control in terms of cost-effectiveness and energy conservation.

Critique

This paper deals in detail with the calculation of net present values and cost/benefit ratios for air-to-air heat exchangers.

BIBLIOGRAPHY (Reference 26)

Title	National Building Code of Canada 1980
Author(s)	Associate Committee on the National Building Code
Publisher/Date/Page	National Research Council of Canada/1980/547 pages
Available from/Price	Associate Committee on the National Building Code Ottawa, Canada $8.75
Catalogue & Indexing	NRCC No. 17303
Key Words	Codes and standards/ventilation requirements
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract	This document comprises a model set of technical requirements for ensuring public safety in buildings. In contains chapters on use and occupancy, design, wind, water and vapour protection, ventilation, plumbing and safety.
Critique	The section on ventilation is somewhat brief. Natural or mechanical ventilation systems are permitted.

BIBLIOGRAPHY (Reference 27)

Title	Residential Standards 1980
Author(s)	National Research Council of Canada
Publisher/Date/Pages	NRC/1980/288 pages
Available from/Price	Associate Committee On The National Building Code National Research Council of Canada Montreal Road, Ottawa, Ontario K1A 0R6 $1.50
Catalogue & Indexing Numbers	NRCC No. 17304
Key Words	ventilation/building codes
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

Residential Standards 1980 contains the requirement for buildings of residential occupancy from Part 9 of the National Building Code of Canada 1980 and further requirements related to residential buildings found under the National Housing Act. It applies to buildings of up to three storeys in height.

Critique

Only a small portion of Residential Standards is devoted to ventilation requirements. Minimum requirements for both mechanical and natural ventilation are prescribed.

BIBLIOGRAPHY (Reference 28)

Title	The Building Code - Ontario Regulation 925/75
Author(s)	Building Code Branch, Ontario Ministry of Consumer and Commercial Relations
Publisher/Date/Pages	Ontario Ministry of Consumer and Commercial Relations/1976/9 parts
Available from/Price	Division of Building Research Library Montreal Road, Ottawa, Ontario K1A 0R6
Catalogue & Indexing Numbers	REF: TH226 0592: BLDG
Key Words	Building standards and codes/design requirements/fire,use and occupancy regulations/ handicapped persons requirements/building services/ construction safety
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This provincial building code is a regulation consisting of building requirements to minimize the risk of injury and property damage from structural failure, fire and health hazards. It is divided into nine parts which cover government administration, occupancy, design and building requirements, handicapped persons, building and plumbing services, construction safety and small buildings.

Critique

The Ontario Building Code is based on the National Building Code and is due to be superceded in 1983 by a revised edition. It is a legal requirement for all construction in Ontario.

BIBLIOGRAPHY (Reference 30)

Title	Measures for Energy Conservation in New Buildings
Author(s)	National Research Council of Canada
Publisher/Date/Pages	NRC/1978/52 pages
Available from/Price	Associate Committee on the National Building Code National Research Council of Canada Montreal Road, Ottawa, Ontario K1A 0R6 $2.00
Catalogue & Indexing Numbers	Report Number NRCC 16574 REF TH266 N278
Key Words	Energy conservation/building systems/design/building code/tables
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This guideline for preparing comprehensive energy conservation measures for new buildings utilizes ASHRAE Standard 90-75 modified to suit Canadian conditions and National Building Code requirements.

Critique

ASHRAE 90-75 is a comprehensive and extremely useful document. This adaptation is a significant contribution to Canadian design of energy conscious building systems. Governing bodies can readily incorporate the contents into code requirements. Since values are presented in metric with British System tables in the Appendix, they are easily utilized by the designer.

BIBLIOGRAPHY (Reference 31)

Title	Energy Conservation In New Building Design
Author(s)	ASHRAE Standard: 90-75
Publisher/Date/Pages	ASHRAE/1975/53 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2
Catalogue & Indexing Numbers	ASHRAE Standard: 90-75 UDC 620.9:69:006: BLDG
Key Words	Building design/energy conservation/exterior envelope/HVAC systems/electrical systems/alternative energy sources
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This Standard sets forth requirements for the design of new buildings such that their exterior envelopes, and selection of their HVAC, service water heating, electrical distribution and illuminating systems and equipment will ensure the most efficient energy usage.

Critique

This standard was in conflict with the old ventilation standard 62-73. This has been resolved with the issuing of the new ventilation standard 62-1981. Since this time, Standard 90-75 has not been quoted as frequently as Standard 62-1981.

BIBLIOGRAPHY (Reference 33)

Title	"Ventilation for Acceptable Indoor Air Quality"
Author(s)	ASHRAE Standard 62-1981
Publisher/Date/Pages	ASHRAE/1981/18 pages
Avialable from/Price	Building Research Library Montreal Road, Ottawa, Ontario K1A 0R6 $4.62 (Photocopy)
Catalogue & Indexing Numbers	ASHRAE 62 - 1981 SER TH 7687.A515
Key Words	Ventilation rate/indoor air quality
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This revised Standard includes a ventilation rate procedure which indirectly controls air quality and a new procedure to permit direct control of the indoor air quality. The objective of the revised Standard is to provide healthful and comfortable indoor environments by using materials and methods that optimize energy efficient usage.

Critique

This is probably the most widely referenced ventilation standard in North America. The alternative methods of controlling air-quality allow the designer flexibility. Possible weaknesses are limited guidelines for air contaminant concentrations. This will be addressed in the next revision.

BIBLIOGRAPHY (Reference 34)

Title	Svensk Bygg Norm (Swedish Building Code: 1980)
Author(s)	
Publisher/Date/Pages	Statens planverks forfattningssamling/1980/607 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 ($0.22 per page photocopy)
Catalogue & Indexing Numbers	SER TH242 S8S S98 1980: 1 BLDG
Key Words	Building codes and standards/energy conservation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract	The Swedish Building Code contains the general requirements for all buildings as well as specific tables of requirements.
Critique	This is a very thorough specification of ventilation requirements and air tightness of housing. It is considered too restrictive by some authorities but has many provisions worthy of consideration.

BIBLIOGRAPHY (Reference 35)

Title	Potential Health Effects of Residential Energy Conservation Measures
Author(s)	G.S. Young, J.H. Hagopian, and E.R. Hoyle
Publisher/Date/Pages	A.D. Little Inc./1981/299 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 (Microfiche: $0.22 per page, photocopy)
Catalogue & Indexing Numbers	U 8205; PB82 - 133315
Key Words	Indoor air pollutants/infiltration measurement techniques/residential ventilation standards/energy conservation/literature review/bibliographies
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This is a literature review and a data collection of the types, sources and concentrations of pollutants found in the residential environment. There are annotated bibliographies of current literature and discussions of studies of residential air infiltration, health related factors and indoor air quality.

Critique

This is a comprehensive summary of relevant work, mostly in the United States up to 1981. Trends in research and government activities are noted.

BIBLIOGRAPHY (Reference 40)

Title	A Study to Determine Contaminant Build-Up In Houses
Author(s)	MacLaren Engineers Planners & Scientists Inc.
Publisher/Date/Pages	National Research Council of Canada/1982/Phase I: 43 pages/Phase II: 29 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2
Catalogue & Indexing Numbers	TH 7699 .C6 5934 - BLDG TH 7699 .C6 5935 (Phase II) - BLDG
Key Words	Infiltration rates/contaminant levels/residential study/radon/radon daughters/formaldehyde
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This two phase report prepared for NRC studied the concentration of radon, radon daughters and formaldehyde in detached houses with low rates of natural ventilation during one winter heating season. The report also studied the frequency of sampling necessary to establish the profile of air contaminants in residences.

Critique

This report reaches some useful conclusions, however, it shows how much further work is required before results can be held valid for a large population.

BIBLIOGRAPHY (Reference 44)

Title	Determination of Airtightness of Buildings By The Fan Depressurization Method - 4th Draft
Author(s)	Canadian General Standards Board
Publisher/Date/Pages	CGSB/1983/13 pages & Appendices
Available from/Price	Canada General Standards Board Ottawa, Ontario K1A 1G6
Catalogue & Indexing Numbers	CGSB 149-GP/10M - 4th Draft
Key Words	Air tightness/building envelope/fan depressurization/ test rates and methods
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract	This standard describes a method to determine the airtightness of a building envelope in small detached buildings (using a fan to exhaust air from the building at rates which will maintain specified pressure differences across the building envelope.
Critique	This standard is becomming increasingly popular across Canada. It is likely that further revisions will be incorporated before it reaches a final form.

BIBLIOGRAPHY (Reference 48)

Title	Market Study of Residential Ventilation in Quebec and Ontario: Etude du Marche de la Ventilation Residentielle Au Quebec et en Ontario
Author(s)	Major & Martin Inc.
Publisher/Date/Pages	Department of Regional Economic Expansion/1983/35 pages/(French) Executive Summary: 5 pages (English)
Available from/Price	DREE Ottawa, Ontario K1A 0M4
Catalogue & Indexing Numbers	Final Report 28 January 1983
Key Words	Market study/mechanical ventilation/heat exchangers/ energy conservation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This departmental study was undertaken to provide an overview of the commercial market of mechanical ventilation systems in Ontario and Quebec for single detached dwellings. The potential market, a market evaluation and manufacturering data is included.

Critique

This is a comprehensive look at the commercial aspects of residential heat exchangers and although devoted in a large part to economics and market size estimations, there are useful sections on theory of operation and a survey of presently available heat exchangers. Only Ontario and Quebec are included in this market study.

BIBLIOGRAPHY (Reference 49)

Title	Building Ventilation and Indoor Air Quality Reports
Author(s)	Lawrence Berkeley Laboratory
Publisher/Date/Pages	Lawrence Berkeley Laboratory/1982/16 pages
Available from/Price	Energy and Environment Division Lawrence Berkeley Laboratory Berkeley, California 94720
Catalogue & Indexing Numbers	July 1982, pp 1 - 16
Key Words	Mechanical ventilation/energy conservation/indoor air pollutants/infiltration/radon concentrations/ heat exchangers
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract	This is a list of all documents issued by the Building Ventilation and Indoor Air Quality Program at Lawrence Berkeley Laboratory since its inception in 1975.
Critique	Although this list is current to mid-1982, some of the later papers are not yet available through the National Technical Information Service.

BIBLIOGRAPHY (Reference 52)

Title	"New Project Committee"
Author(s)	ASHRAE
Publisher/Date/Pages	ASHRAE/1983/1 page
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $0.22 (photocopy)
Catalogue & Indexing Numbers	SER TP490 A11 ASHRAE Journal March 1983
Key Words	Codes and standards/energy conservation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract	This article details the purpose and scope of a new ASHRAE Standards Project Committee with the title "Energy Conservation in New Building Design".
Critique	This committee will deal with updating the existing ASHRAE Standard 90-1975.

BIBLIOGRAPHY (Reference 53)

Title	1982 Annual Book of ASTM Standards Part 18
Author(s)	American Society for Testing and Materials
Publisher/Date/Page	ASTM/1982
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2
Catalogue & Indexing	REF. SER T4A4 S71
Key Words	Codes and standards/fan pressurization tests/tracer gas tests/tracer dilution
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

The relevant standards (E 741-80 Measuring Air Leakage Rate by the Tracer Dilution Method and E779-81 Measuring Air Leakage by the Fan Pressurization Method) detail the scope, apparatus and procedures for conducting these tests.

Critique

These standards are not widely used in Canada however they provide useful reference and comparisons to existing Canadian standards.

BIBLIOGRAPHY (Reference 54)

Title	A Subject Analysis of the AIC's Bibliographic Database - AIRBASE
Author(s)	C. Thompson
Publisher/Date/Pages	Air Infiltration Centre/1982/52 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2
Catalogue & Indexing Numbers	TH7674 T255 AIC-TN-8-82
Keywords	air infiltration/leakage rates/bibliography
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

The Air Infiltration Centre data base, established by the International Energy Agency, provides bibliographic details and abstracts of published papers covering air infiltration in buildings and related subjects. Contents include the prediction, measurement and reduction of air infiltration and leakage. This analysis of the 875 articles in the data base makes references according to subject matter and author.

Critique

This technical note is an extremely useful summary of international research that is not available from any other source. A possible drawback is that abstracts are not provided.

BIBLIOGRAPHY (Reference 55)

Title	Annex IX Minimum Ventilation Rates - Literature Review, Standards and Current Research-Summary 1
Author(s)	International Energy Agency
Publisher/Date/Pages	International Energy Agency/1981/17 pages
Available from/Price	George Tamura - Division of Building Research National Research Council of Canada Montreal Road, Ottawa, Ontario K1A 0R6
Catalogue & Indexing Numbers	IEA: Annex IX - August 1981 Energy Conservation In Buildings and Community Systems Program
Key Words	Energy conservation/air infiltration/ventilation rates/guidelines/codes and standards/air quality
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

In order to establish common criteria to determine ventilation rates and to prepare a research and development programme to solve standardising problems, this review summarizes the relevant literature, the existing proposed standards and the ongoing research on a national scale.

Critique

This is a most useful summary of European, Nordic and North American codes, literature and research. It also provides a list of contacts in all participating countries. Availability is somewhat limited.

BIBLIOGRAPHY

Title	Air-Vapour Barriers
Author(s)	D. Eyre and D. Jennings
Publisher/Date/Pages	Energy, Mines and Resources Canada/1983/84 pages
Available from/Price	Energy, Mines and Resources Canada Energy Conservation & Oil Substitution Branch 580 Booth Street Ottawa, Ontario K1A 0E4
Catalogue & Indexing Numbers	Energy Conservation Technology for Buildings
Key Words	Vapour barrier/humidity control/construction methods
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This report summarizes current practice for the installation of air-vapour barriers. As the name implies, these barriers serve to control air leakage as well as vapour movement. Numerous diagrams showing construction details in all parts of the house are provided.

Critique

This is a very practical report that is written in an easily readable and understandable style. Much of the recommended practice was derived from field experience with energy efficient homes.

BIBLIOGRAPHY

Title	Promise and Potential of Air-to-Air Energy Recovery Systems
Author(s)	H.J. Sauer and R.H. Howell
Publisher/Date/Pages	ASHRAE Transactions/1981/16 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $3.52 (photocopy)
Catalogue & Indexing Numbers	SER TH 7201 A53 t 7 ASHRAE No. 2621 RP-173
Key Words	Energy recovery devices/energy conservation/building design/heat exchangers
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This paper describes the principles, advantages and disadvantages of several types of air-to-air energy recovery devices including: open and closed run-around systems, the heat pipe exchanger, the thermal wheel, and the plate exchanger.

Critique

A computer is used to simulate several types of energy recovery devices, some of which are not suitable for residential use.

BIBLIOGRAPHY

Title	"Ventilation Requirements and Natural Air Leakage in Residences"
Author(s)	W.R. Jones and S. Stricker
Publisher/Date/Pages	Ontario Hydro Research Review/1981/5 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $1.10 (photocopy)
Catalogue & Indexing Numbers	SER TK1 061 No. 4, pp 17 - 20, December 1981
Key Words	Natural air leakage/ventilation requirements/leakage measurements/air contaminants/heat recovery
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This article discusses the problem of natural air leakages in residences with reduced air infiltration with regards to techniques for measuring air leakage, the contaminants to be controlled, mechanical ventilation control methods and recommendations for further research.

Critique

This is a general discussion of ventilation requirements and influencing factors and includes a useful section on areas requiring future work.

BIBLIOGRAPHY

Title	Mobile Home Appliance Standards and Super Energy Efficient Homes (SEEH) - Working Document
Author(s)	Canadian Standards Association
Publisher/Date/Pages	Ontario Research Foundation/1983/19 pages
Available from/Price	Energy, Mines and Resources Conservation and Renewable Energy Branch 580 Booth St., Ottawa, Ontario K1A 0E4
Catalogue & Indexing Numbers	Ontario Research Foundation, Sectorial Task 3.16 - Technical Review for Super Energy Efficient Homes
Key Words	Fuel-burning appliances/super energy efficient houses/mobile homes/codes and standards
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

The report reviews existing mobile home fuel-burning appliance standards and assesses their applicability to SEE housing. It includes a current list of fuel-burning appliances certified for use in mobile homes.

Critique

This is a comprehensive summary of topics as listed above.

BIBLIOGRAPHY

Title	"Ventilation, Health & Energy Combustion: A Status Report"
Author(s)	J.E. Woods
Publisher/Date/Pages	ASHRAE Journal/1979/5 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $1.10 (photocopy)
Catalogue & Indexing Numbers	TP 490 A 11 July 1979, pp 23 - 27
Key Words	Ventilation requirements/codes and standards/indoor air contaminants/ventilation equipment and systems/ energy conservation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This status report focuses on the health, safety and welfare of occupants in light of arbitrary changes to codes and standards. The possibility of insufficient ventilation in new buildings and the need for performance specifications of ventilation systems are reviewed.

Critique

This is a useful discussion, current to 1979, of actual and possible effects of current and proposed changes in building codes and standards.

BIBLIOGRAPHY

Title	Air Infiltration Measurement Techniques
Author(s)	M.H. Sherman, D.T. Grimsrud, P.E. Condon and B.V. Smith (Lawrence Berkeley Laboratory)
Publisher/Date/Pages	Air Infiltration Centre - Conference/1980/34 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $7.48 (photocopy)
Catalogue & Indexing Numbers	TH 7678 A288 1980
Key Words	Infiltration measurement/tracer gas
Sector Applicability	Office Residential Restaurant Industrial Retail

Abstract

This paper presents a survey of tracer-gas techniques for measuring air infiltration and includes a theoretical derivation of the equations, a description of each method, and a short description of the experimental procedure.

Critique

This is a mainly theoretical discussion but also emphasizes advantages and disadvantages of each technique.

BIBLIOGRAPHY

Title	A Model Correlating Air Tightness and Air Infiltration in Houses
Author(s)	A.K. Blomsterberg, M.H. Sherman and D.T. Grimsrud
Publisher/Date/Pages	ASHRAE Conference: Proceedings/1979/16 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $3.52 (photocopy)
Catalogue & Indexing Numbers	TJ 163.5.B84 T411-1979
Key Words	Infiltration/leakage/ventilation/neutral pressure level
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

The model in this paper represents a technique of correlating the two methods used to measure air infiltration in buildings: the fan pressurization technique and the tracer gas technique. The new model includes the neutral pressure level to estimate the distribution of openings around the building envelope and it is applied here to houses in New Jersey and California.

Critique

The work in this paper is a step in determining if a correlation can be developed. By itself it has limited practical value.

BIBLIOGRAPHY

Title	Natural Ventilation By Design: Symposium
Author(s)	The Chartered Institute of Building Services
Publisher/Date/Pages	The Chartered Institute of Building Services/1980/63 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2
Catalogue & Indexing Numbers	TH 7674 N285 1980
Key Words	Natural ventilation/occupancy comfort/indoor air contaminants/energy conservation
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

The six papers presented at this symposium cover the following topics related to natural ventilation by means of design: ventilation requirements, natural ventilation design principles, ventilation measurements in housing, problems in commercial and industrial ventilation, ventilation in the modern hospital, and natural ventilation in government department buildings.

Critique

The first two papers contain useful general information on natural ventilation theory and pressure measurement methods.

BIBLIOGRAPHY

Title	"Ventilation Requirements"
Author(s)	Building Research Establishment Digest
Publisher/Date/Pages	Building Research Establishment/1977/8 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2 $1.76
Catalogue & Indexing Numbers	Ser TH1 B93 206 1977
Key Words	Indoor air contaminants/fresh air requirements/ dilution rates
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This digest article discusses fresh air requirements and tolerable levels of contamination from various sources and explains the calculation of dilution rates, specifically during the heating season.

Critique

This article contains useful information on dilution and odour control techniques.

BIBLIOGRAPHY

Title	Building Design for Minimum Air Infiltration
Author(s)	Air Infiltration Centre
Publisher/Date/Pages	AIC Conference Proceedings/1981/215 pages
Available from/Price	CISTI Montreal Road, Ottawa, Ontario K1A 0S2
Catalogue & Indexing Numbers	TH7678 A288 1981
Key Words	Indoor air quality/minimum ventilation/energy conservation/air leakage/air infiltration
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

The proceedings include sixteen papers which study the design of buildings in order to minimize the infiltration of air. The focus is on obtaining and testing indoor air quality, energy conservation, and acceptable air infiltration and ventilation patterns.

Critique

These proceedings contain several useful papers on air infiltration meaurements and tracer gas measurements.

BIBLIOGRAPHY

Title	Ventilation: State-of-the-Art Review
Author(s)	Saul Stricker, Ontario Hydro
Publisher/Date/Pages	Canadian Electrical Association/1980/34 pages
Available from/Price	Canadian Electrical Association Research & Development Suite 580, One Westmount Square, Montreal, Quebec H3Z 2P9
Catalogue & Indexing Numbers	Ontario Hydro Report 918 U - SOA June 11, 1980
Key Words	Ventilation requirements/air contaminants/air leakage measurements/air infiltration/heat recovery
Sector Applicability	Office Residential Restaurants Industrial Retail

Abstract

This paper reviews the ventilation requirements for residential buildings, the recently discovered contaminants of indoor air which influence required ventilation rates, methods of measuring air leakage and air infiltration rates and the role of heat recovery devices.

Critique

This paper quotes useful allowable contaminant levels and associated ventilation rates and outlines areas requiring future work. All this is current to 1980.

APPENDIX A

ORGANIZATIONS CONTACTED

ORGANIZATIONS CONTACTED

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